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CALIBRATION OF SONIC FLOWMETERS FOR OCEAN THERMAL ENERGY CONVER--ETC(U)
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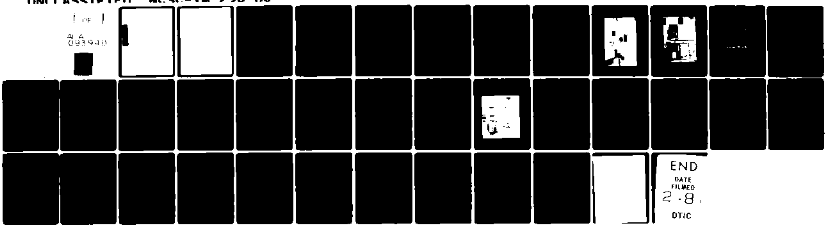

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A commercially available acoustic flowmeter has been used at Naval Coastal Systems Center (NCSC) at Panama City, Florida, to monitor critical flow conditions relative to the effects of biofouling on the efficiency of a prototype heat transfer system during the OTEC (Ocean Thermal Energy Conversion) funded study. This report documents the special procedures devised by NCSC personnel to calibrate the flowmeters. Seawater pumped through the flowmeter into a tank suspended beneath a special load cell

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INTRODUCTION

Scientists at the Naval Coastal Systems Center (NCSC) at Panama City, Florida, have used a commercially available acoustic flowmeter to monitor critical flow conditions during an OTEC (Ocean Thermal Energy Conversion) funded study of the effects of biofouling on the efficiency of a prototype heat transfer system. Flowmeters of this type are particularly useful in applications requiring unimpeded flow; i.e., no sensor projecting into the moving fluid. Unfortunately, sonic flowmeters are somewhat difficult to calibrate and may be subject to drift. A method of calibration devised by NCSC may thus be of some interest to other users. It is the purpose of this report to document the special procedures used by test personnel to calibrate the flowmeters.

Briefly, the calibration consisted of pumping sea water through the flowmeter into a tank suspended beneath a special load cell which provided an output voltage proportional to the weight of water in the tank. A programmable desktop calculator system was used to monitor changes in voltage as a function of time, and convert these changes into flow rates for direct comparison with values read from the sonic flowmeter's digital display. Calibration checks were made at metered flows of 8, 10, 12, 14, 16, and 18 gallons per minute (gpm). It was found that computed flows were essentially linear but differed from metered values by as much as 9.0 percent.

This report is organized into two main sections; the first contains pertinent background information and the second section provides a detailed description of the calibration setup, procedures, and results.

BACKGROUND

OTEC envisions the production of electricity (or energy-intensive chemicals) from the characteristic thermal differences which exist between the warm water found near the ocean's surface and the cold water found at the depth.[1] In tropic and subtropic latitudes, surface waters range from 20 to 25 degrees Clesius warmer than the water 1000 metres beneath the surface. This thermal difference is sufficient to vaporize ammonia for driving a turbine and to condense ammonia as required in a closed-loop system. However, heat exchanger efficiency may be severely curtailed if biofouling organisms accumulate on exchanger substrates exposed to sea water. Consequently, NCSC was commissioned by OTEC to conduct an in situ study on the effects of biofouling (and biofouling countermeasures) on heat transfer. A unique test facility was constructed

[1]Griffin, O. M., "OTEC, Power from Thermal Gradients," *Sea Technology*, pp 11-15, August 1977.

on the Center's ammunition pier in St. Andrew Bay where various experiments were conducted during the past 2 years. It was during these experiments that NCSC investigators came to grips with the concept of biofouling "resistance" and problems associated with the calibration of sonic flowmeters.

The term "biofouling resistance" is widely used in OTEC literature. Contrary to intuitive notion, it has little to do with the increased drag which one might expect as sea water flows over a fouled surface. Rather, OTEC defines it as a measure of the increased difficulty of transferring heat through a fouled surface as compared to that of transferring it through the same surface free of fouling. Computation of fouling resistance is based on a method devised by Wilson.[2] Details of his method, as it applies to the NCSC experiments, are provided in Appendix A. The sample plot depicted in Figure 1 reveals that fouling resistance is not a simple constant but varies considerably with changes in flow velocity. Accurate measurements of flow are thus needed in order to compute fouling resistance; hence, the requirement for a reliable flowmeter and a method of calibrating it in place.

FLOW MEASUREMENT

NCSC investigators monitored flow by means of a Series 240 Clampitron Flowmeter manufactured by the Controlatron Corporation of Hauppauge, New York. The flow measurement system consisted of three main components: (1) a pair of Series 240 transducers; (2) a Series 241 flow display computer; and (3) a Series 242 ten-channel multiplexer. A typical transducer setup is pictured in Figure 2; display and multiplexer units are shown in Figure 3. A schematic diagram of a simple flowmeter system is provided in Figure 4. In principle, variations in flow through a section of pipe are detected by means of corresponding changes in the velocity of the ultrasonic beam projected obliquely across the pipe from one transducer to the other. The primary advantage of this system is that the flow patterns within the pipe are not interrupted by obstructing sensors. Output is, then, independent of fluid scalar properties such as temperature, density, and corrosion. Additionally, the system can be easily attached to existing piping and readily used by non-technical personnel. Finally, the system's multiple channel capability, plus options for operation in analog or totalizer mode, simplify problems of interfacing with larger computers for control and monitoring purposes.

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[2]Wilson, E. E., "A Basis for Rational Design of Heat Transfer Apparatus," *American Society of Mechanical Engineers Transactions*, Vol. 37, ASME Paper No. 1477, 1915.

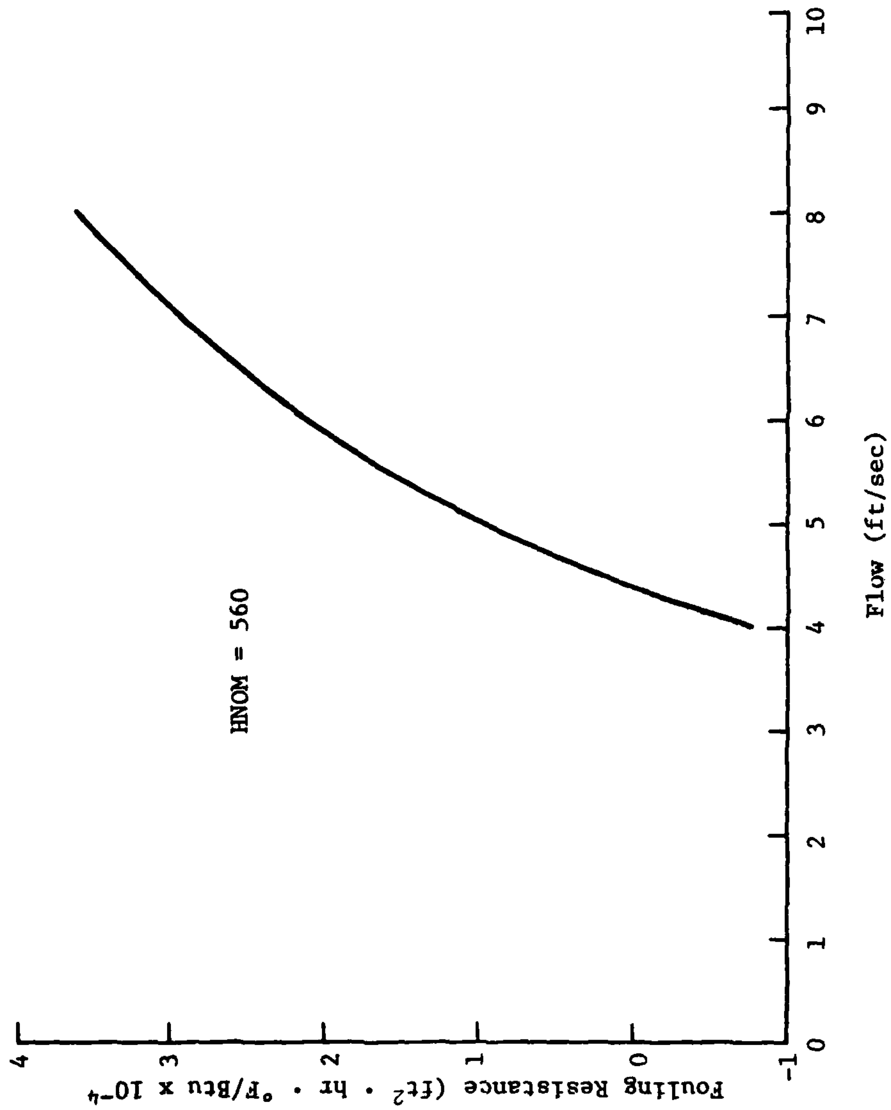

FIGURE 1. EFFECT OF FLOW ON FOULING RESISTANCE

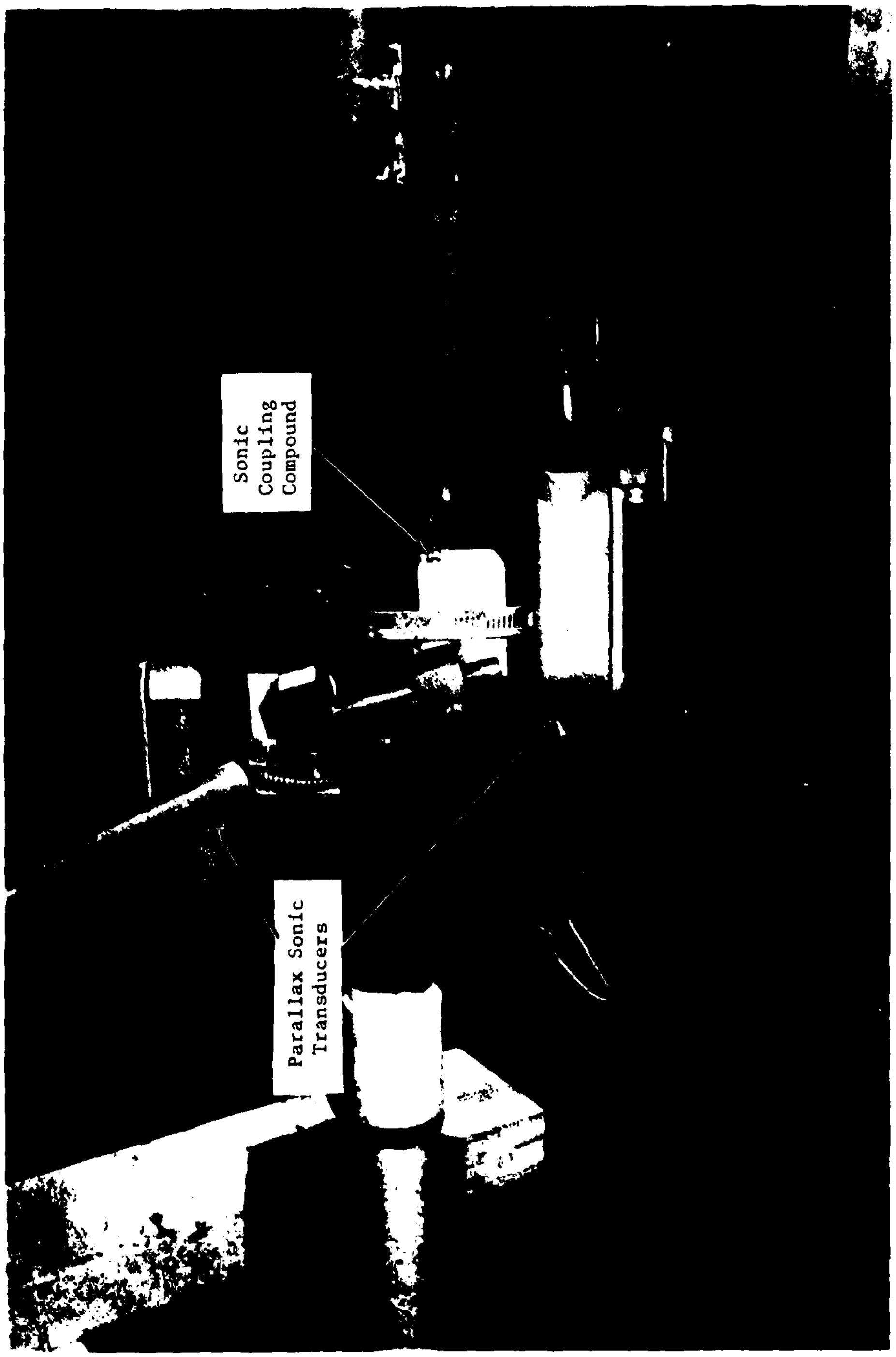

FIGURE 2. TRANSDUCERS CLAMPED TO PIPE

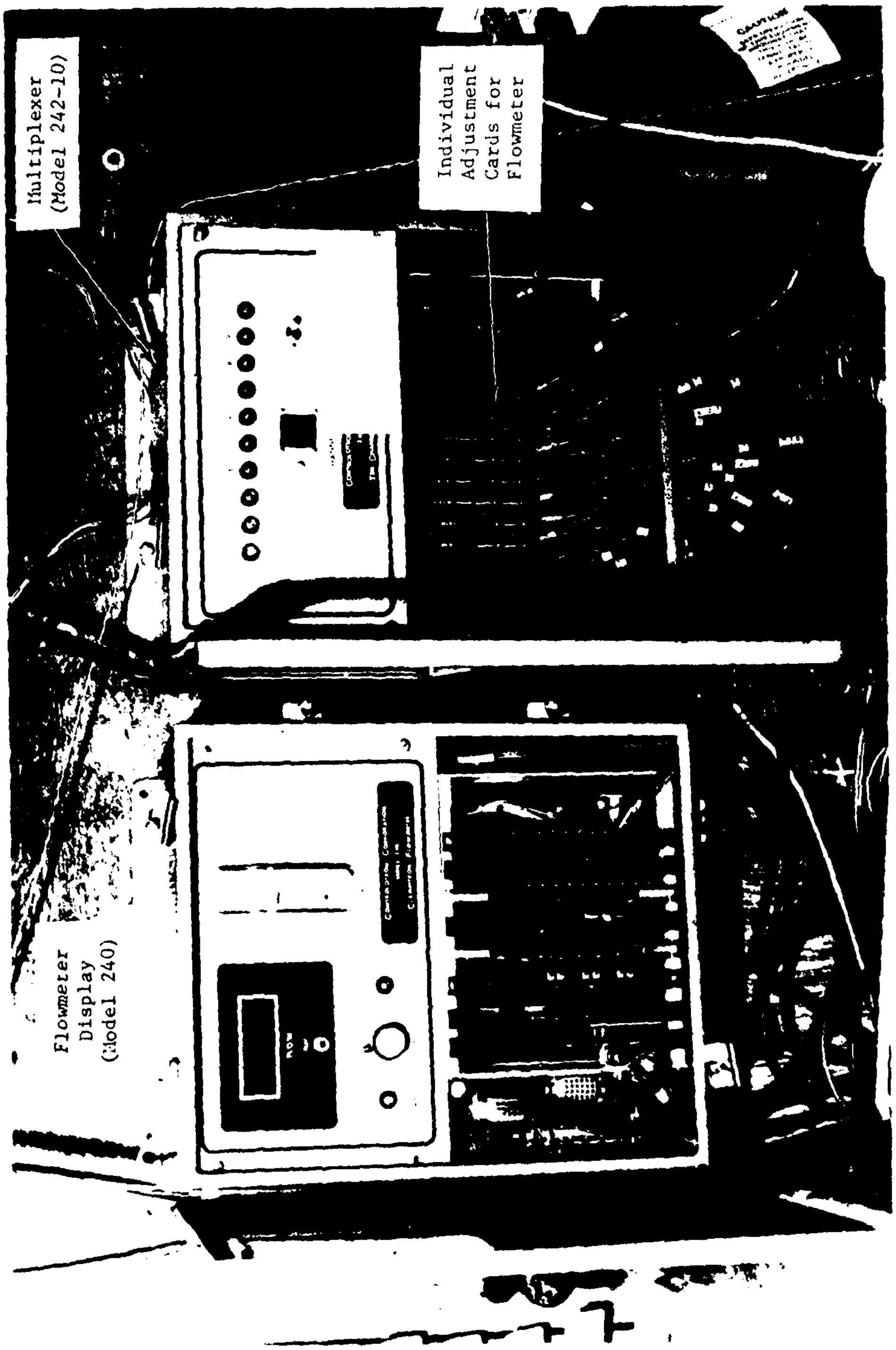

FIGURE 3. FLOWMETER DISPLAY AND MULTIPLEXER UNITS

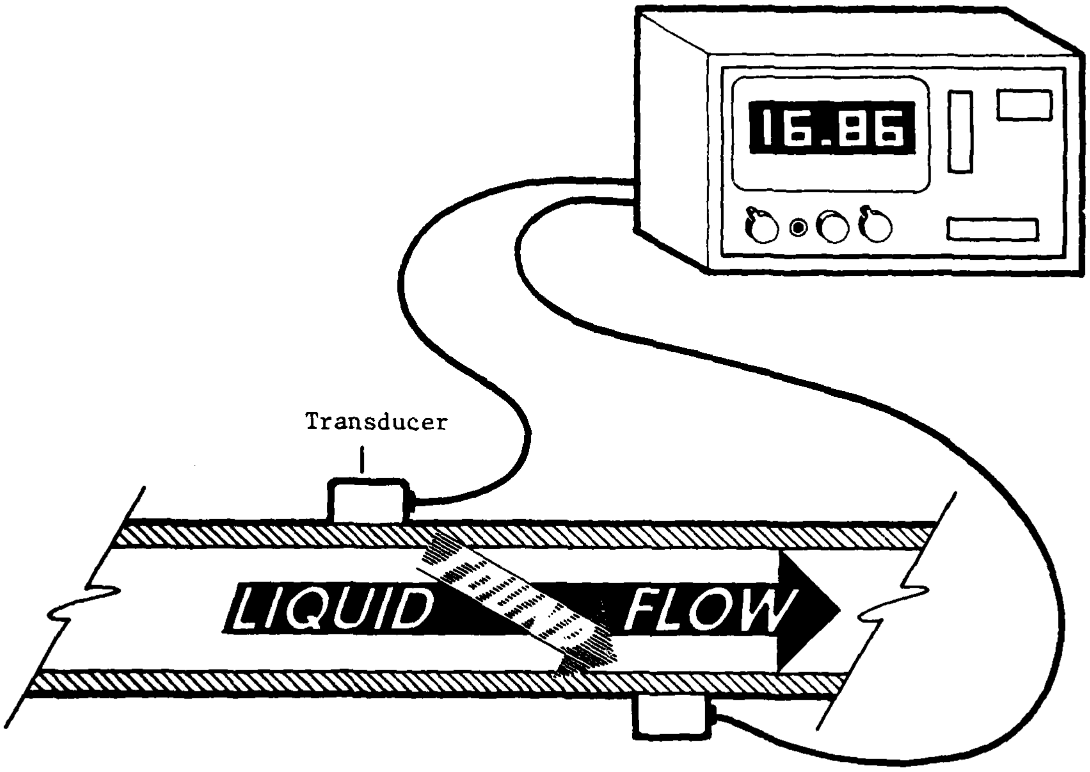

FIGURE 4. PRINCIPLE OF OPERATION OF A SIMPLE SONIC FLOWMETER SYSTEM

A total of 10 pairs of transducers was used in the NCSC experiments, thereby providing flow measurements from up to 10 locations within the system. Techniques to monitor and analyze data were developed by Fetkovitch[3] and modified in-house by Tuovila[4 5] from software provided by Boswell.[6] Experimental setup, procedures, and results are discussed at length in References 7 through 9. A detailed description of the method employed by NCSC to calibrate flowmeters is provided in the next section of this report.

FLOWMETER CALIBRATION

CALIBRATION SYSTEM

The system for calibration of the Clampitron flowmeters was devised by Mr. C. E. Hodges and implemented by D. F. Lott, C. E. Hodges, R. T. Casler, R. H. Payne, and G. G. Salsman. As shown in Figure 5, the system consisted

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[3]Fetkovitch, J. G., Fette, C. W., Findley, R. W., Grannemann, G. R., Mahlingham, L. M., Meier, D. L., and Runco, P. D., *"A System for Measuring the Effect of Fouling on Heat Transfer under Simulated OTEC Conditions,"* Report COO-4041-10, Carnegie-Mellon University, December 1976.

[4]Tuovila, Susan M., *"Data Analysis for Ocean Thermal Energy Conversion (OTEC),"* Naval Coastal Systems Center Technical Memorandum TM 271-79, November 1979.

[5]Tuovila, S. M., *"Software Configuration of Ocean Thermal Energy Conversion (OTEC) at Panama City, Florida,"* Naval Coastal Systems Center Technical Memorandum (in preparation).

[6]Boswell, D., *"Data Acquisition System Design and Integration for the Ocean Thermal Energy Conversion Biofouling Test,"* David Taylor Naval Ship Research and Development Center Technical Report (in preparation), 1980.

[7]Braswell, J. A., Lott, D. F., and Hedlicka, S. M., *"Preliminary Evaluation of Flow-Driven Brushes for Removal of Soft Biofouling from Heat Exahnger Tubes in OTEC Power Plants,"* Proceedings of the Ocean Thermal Energy Conversion (OTEC) Biofouling Corrosion and Materials Workshop, January 8-10, 1979, Rosslyn, Virginia.

[8]Lott, D. F. and Tuovila, S. M., *"Fouling Countermeasures--Status of Two Mechanical Cleaning Systems and Chlorination,"* Proceedings of the Sixth OTEC Conference, Washington, D. C., June 1979.

[9]Lott, D. F. and Tuovila, S. M., *"In Situ Cleaning of OTEC Heat Exchangers,"* Proceedings of the Seventh OTEC Conference, Washington, D. C., June 1980.

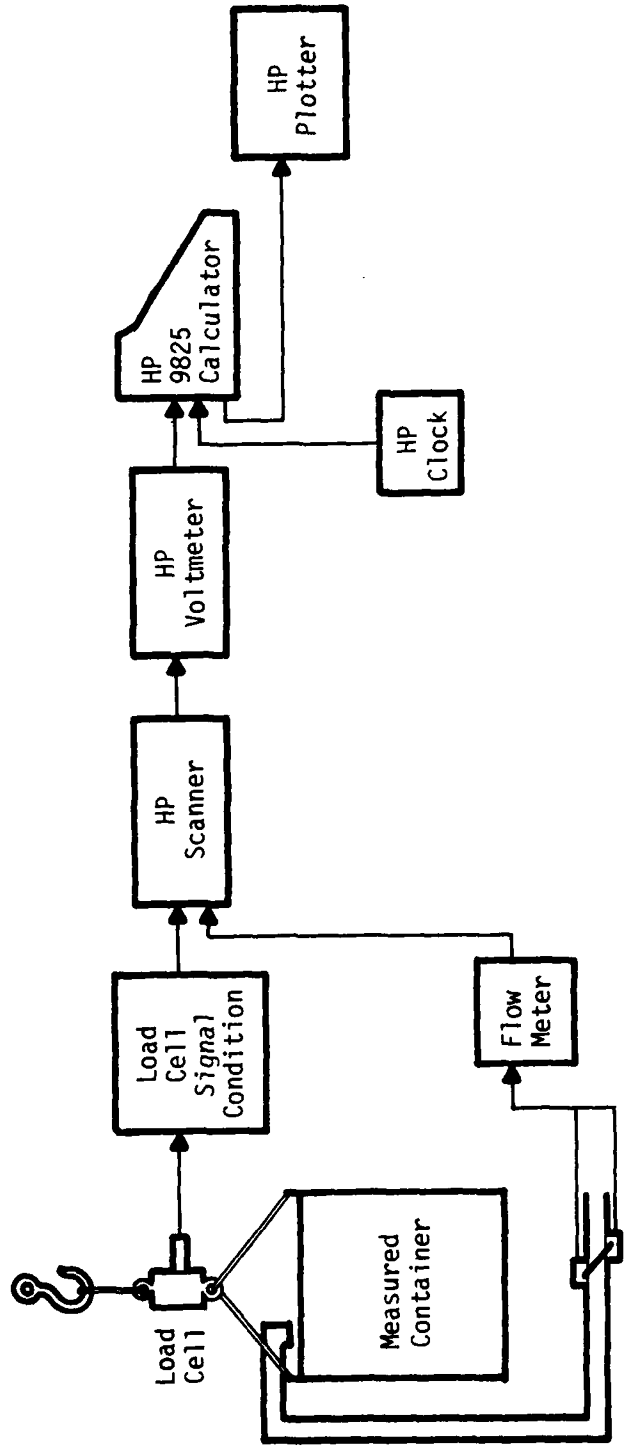

FIGURE 5. CALIBRATION SYSTEM FOR SONIC FLOWMETERS

of a Hewlett-Packard (HP) Model 9825A Controller, HP3437A Digital Voltmeter, HP3495A Scanner, HP98035A Real Time Clock, HP9862A Plotter, a mechanical hoist, a 48-gallon catch tank, and a Baldwin, Ling, and Hamilton (BLH) SR4 Load Cell (Type U-1).

CALIBRATION SYSTEM VALIDATION

Basically, the calibration consisted of pumping sea water through a given flowmeter into a catch tank hanging beneath the system load cell which provided an output voltage proportional to the weight of water in the tank. The system controller was programmed to monitor changes in voltage as a function of time and convert these changes into flow rates for direct comparison with values read from Clampitron's digital display.

A set of four computer programs was used to perform the desired calibrations. The first program enabled test personnel to determine the functional relationship between the output voltage of load cell and the volume of water in the tank. The second program monitored raw voltage outputs of load cell and flowmeter during the interval the tank was being filled. The third program recalled voltages from tape storage, converted load cell outputs to gallons of water, and provided a plot of flow volume as a function of time. The fourth program compiled data from various calibration runs and provided a comparative plot of measured flow versus metered flow for each flowmeter tested. Listouts of these HP9825 programs are presented in Appendix B.

The functional relationship between output voltage of load cell and volume of water in tank was determined by: (a) pouring sea water into the tank in carefully measured 5-gallon increments; (b) recording output voltage corresponding to each increment; and (c) performing a least squares fit on the resulting data (recorded values are listed in Appendix C). It was found that:

$$G = -12.5242 + 120.5238V$$

where G is the number of gallons and V is the load cell voltage.

As shown in Figure 6, linearity of fit was essentially perfect. The coefficient of determination (r^2) was 0.99999. The above equation was keyed into subsequent plot programs and stored on magnetic tape for later recall.

The second and most important phase of entire calibration routine consisted of monitoring the raw voltage outputs of the load cell and flowmeter during each interval the tank was being filled. Preparation for this phase entailed emptying the tank and establishing a flow of desired magnitude (as indicated in Clampitron display) through flowmeter of interest, with discharged water passing directly back into the bay. The monitor program was then initiated and discharge was diverted into the catch tank. The scanner and digital voltmeter were programmed to read voltages (from the load cell and flowmeter) upon receipt of a pulse from the HP Real Time Clock. The latter was set up on a periodic interrupt basis and provided pulses at a user-specified rate of either

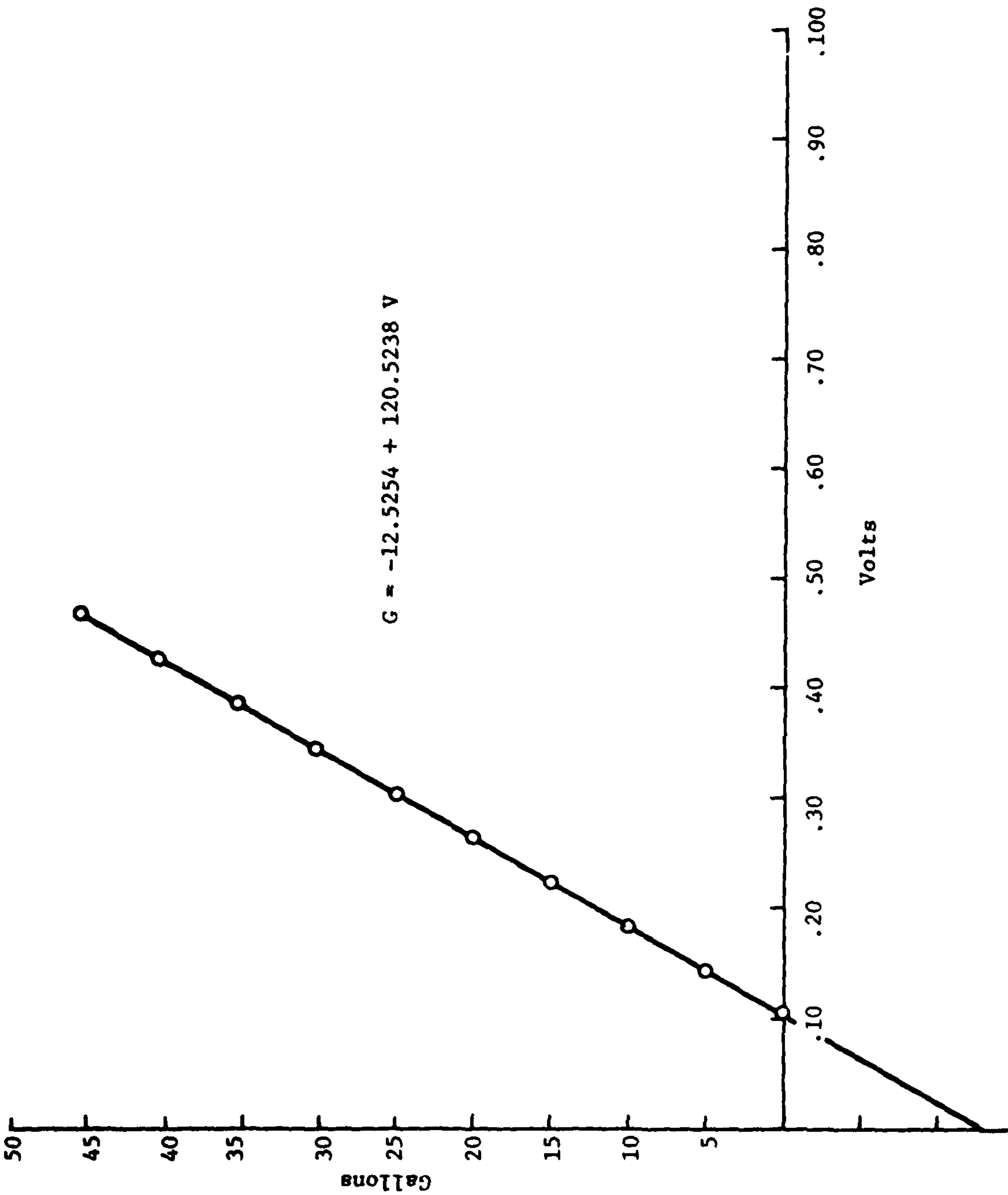

FIGURE 6. GALLONS VERSUS VOLTS IN FLOW CALIBRATION

one or two pulses per second. Up to 600 sets of voltage readings could be obtained during a single fillup (calibration run). Readings were fed into a 600-row by two-column data array which was stored on magnetic tape at the end of each calibration run. Separate runs were made at metered flows of 8, 10, 12, 14, 16, and 18 gallons per minute. Three flowmeters were calibrated in this manner. These meters were assigned names (or ID codes) corresponding to the pipe or tube to which transducers were attached. Calibrations were performed on Tubes No. 1, 4, and 5. Information regarding flowmeter identify, flow setting, sample interval, number of samples obtained, and storage location (track and file) of data from each run are listed in Appendix D.

Upon completion of the first calibration run, data were fed back into a rudimentary plot program to verify that the system was functioning properly. Load cell voltages were converted to gallons in this routine. The resulting plot is presented in Figure 7, where it can be seen that flow rate (slope of curve) was essentially linear. Minor perturbations appearing in the plot were caused by electronic noise (picked up via various circuit components) and by vibrations set up in the tank during the filling process. These perturbations made it unfeasible to compute flow rate on a second-by-second basis. Subsequent values were computed on the basis of averages obtained over 1-minute intervals, thereby filtering out observed jitter and providing sufficient accuracy for calibration purposes.

The final step in the calibration process was to compile the data obtained during all 18 runs (six flow settings for each of three flowmeters tested). Resulting values are listed in Table 1. Also listed in this table are the differences between measured flow and metered flow during each run. Actual flow through Tube No. 4 ranged from 3.5 to 6.7 percent less than flow indicated by meter, while flows through Tubes No. 1 and No. 5 ranged from 5.4 to 8.0 percent greater than metered values. Comparative plots of measured versus metered flow (for all three flowmeters) are presented in Figure 8, where it can be seen that the response of each flowmeter was essentially linear but slopes differed slightly, and significant departures from expected values (dashed line) were encountered. It was concluded that these departures were of sufficient magnitude that appropriate correction routines would have to be included as an essential part of the analysis of flow rate data from related OTEC experiments.

FLOWMETER CALIBRATION PROCEDURES

Calibration of individual flowmeters was accomplished through the following steps:

1. Zero flowmeters to be calibrated

2. Load Test Program

3. Press Run Execute

4. Returns "ID's = "

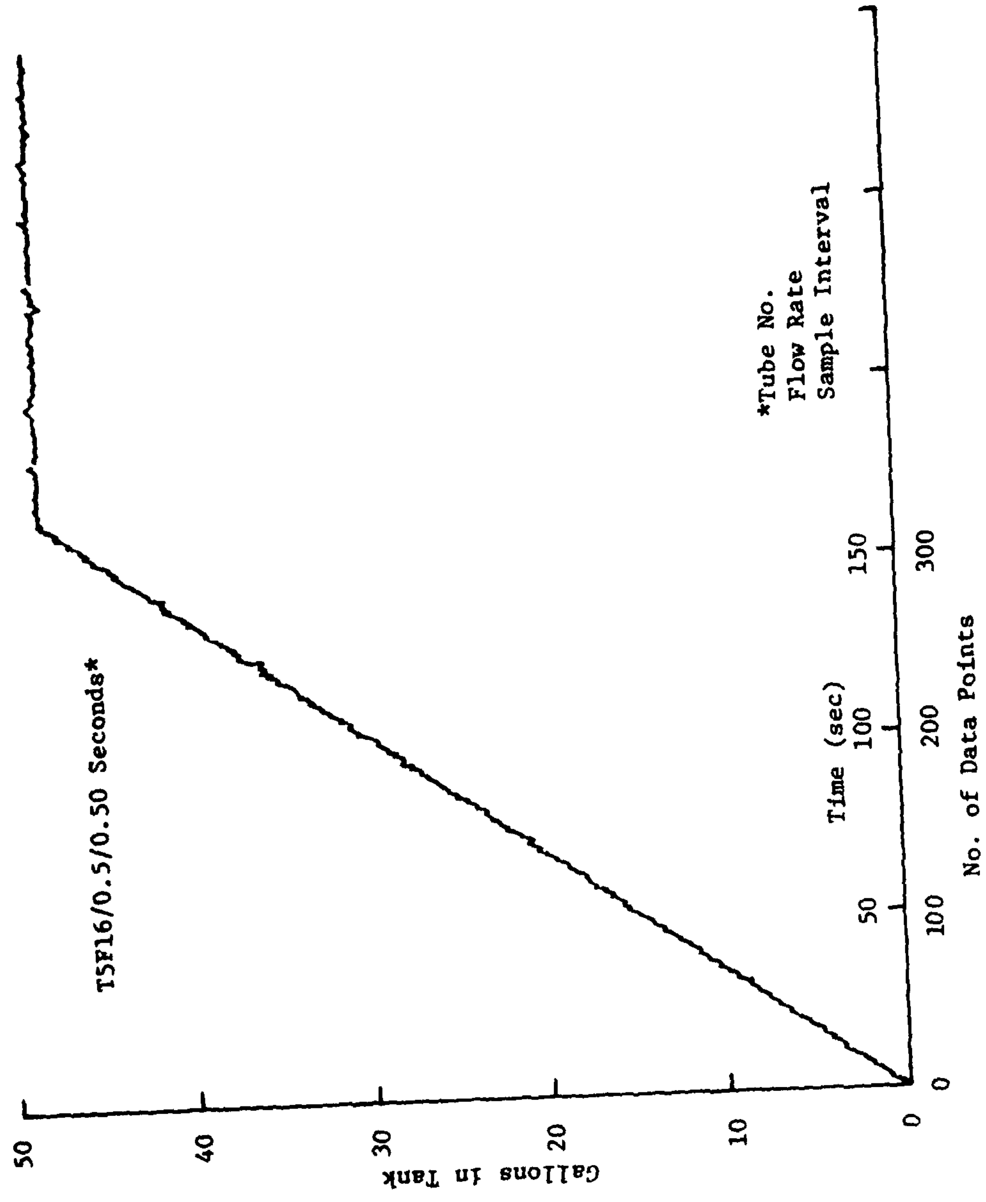

FIGURE 7. PLOT OF GALLONS VERSUS DATA POINTS AND TIME

TABLE 1

VARIABILITY IN FLOW MEASUREMENT BETWEEN METERED AND MEASURED FLOWS IN TUBES 1, 4, AND 5

Tube	FLOWRATE				$\overline{X}$	
	Measured (Gal/Min)	Metered (Gal/Min)	Difference (Gal/Min)	Difference (%)	(Gal/Min)	(%)
T5F18	18.83	17.82	1.0	5.4		
T5F16	16.56	15.67	0.89	5.6		
F5F14	14.29	13.41	0.88	6.2		
T5F12	12.47	11.72	0.75	6.0		
T5F10	10.64	9.90	0.74	7.0		
T5F8	8.51	7.96	0.55	6.5	0.89	6.1
T4F18	16.80	17.42	-0.62	-3.7		
T4F16	15.50	16.04	-0.54	-3.5		
T4F14	13.41	13.98	-0.57	-4.3		
T4F12	11.40	11.92	-0.52	-4.6		
T4F10	9.43	9.90	-0.47	-5.0		
T4F8	7.35	7.84	-0.49	-6.7	0.54	-4.6
T1F18	17.16	15.79	1.37	8.0		
T1F16	19.21	17.81	1.40	7.3		
T1F14	15.04	13.87	1.17	7.8		
T1F12	12.95	11.92	1.03	8.0		
T1F10	10.90	10.03	0.87	8.0		
T1F8	8.59	7.81	0.78	9.1	1.10	8.03

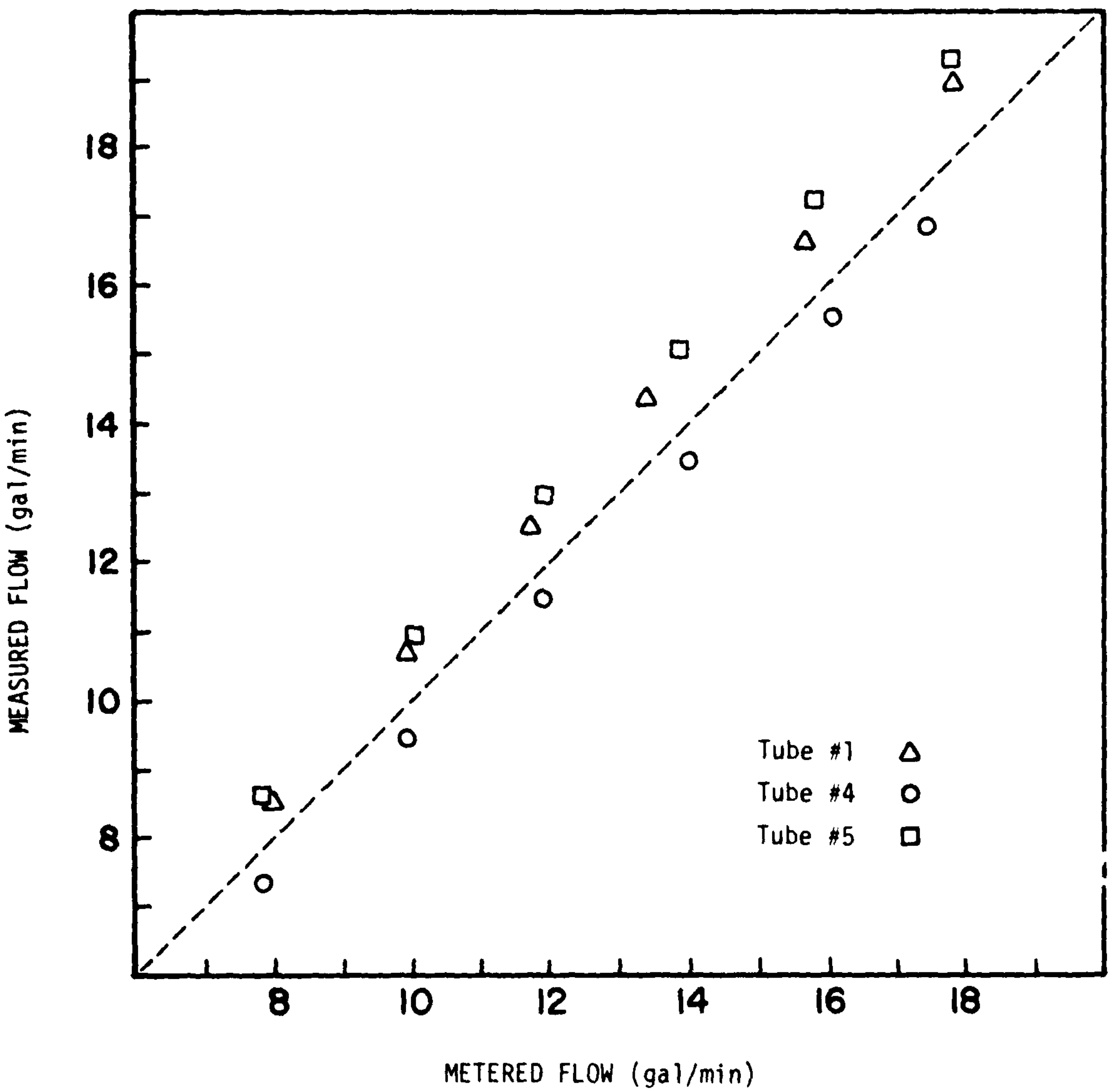

FIGURE 8. COMPARISON OF MEASURED AND METERED FLOW RATES THROUGH TUBES 1, 4, AND 5

At this point the tube number, flow, and sampling interval are used to identify the calibration test. A typical example is:

T5F16.5

Tube # (T5) Sampling interval (0.5)

Flow rate (F16)

5. Input ID Code, Execute

6. Returns "Sampling Interval (Sec) = ". Usually input is "1.0" or "0.5" depending on flow rate.

7. Input number of seconds between sample intervals, Execute

8. Returns "Press CONTINUE to Begin"

The program now waits for the command to begin. At this point, flow through the metered section is in close proximity to the barrel of known volume suspended from the load cell. As the water enters the barrel, the operator pushes "CONTINUE" and monitoring begins. Note that a visual requirement exists for the operator to start monitoring.

9. Press CONTINUE to initiate monitoring

10. Press STOP

As water reaches the maximum measured volume, another visual observation by the operator, the operator presses STOP.

11. Returns "Storage File Number = "

Data are stored on magnetic tape. See Appendix E for a list (catalog) of files used. Data are stored in a file of 9700 byte size.

12. Input file number execute

13. Returns "Track Number = "

HP9825 Magnetic Tapes have a capability to use a single tape for two tracks of data designated "trk 0" and "trk 1."

14. Input track number

This track must be previously makred as indicated in Appendix E.

15. Returns number of points, measured flow value, metered flow value to two decimal points.

If the measured and metered flows do not match, adjust the flowmeter card by setting the SCALE INT-EXT switch to the EXT position (Figure 9). This bypasses the internal factory calibration. The SCL switch is adjusted and another set of data prints is taken. Using successive adjustments, metered flow rate was equal to measured flow rate.

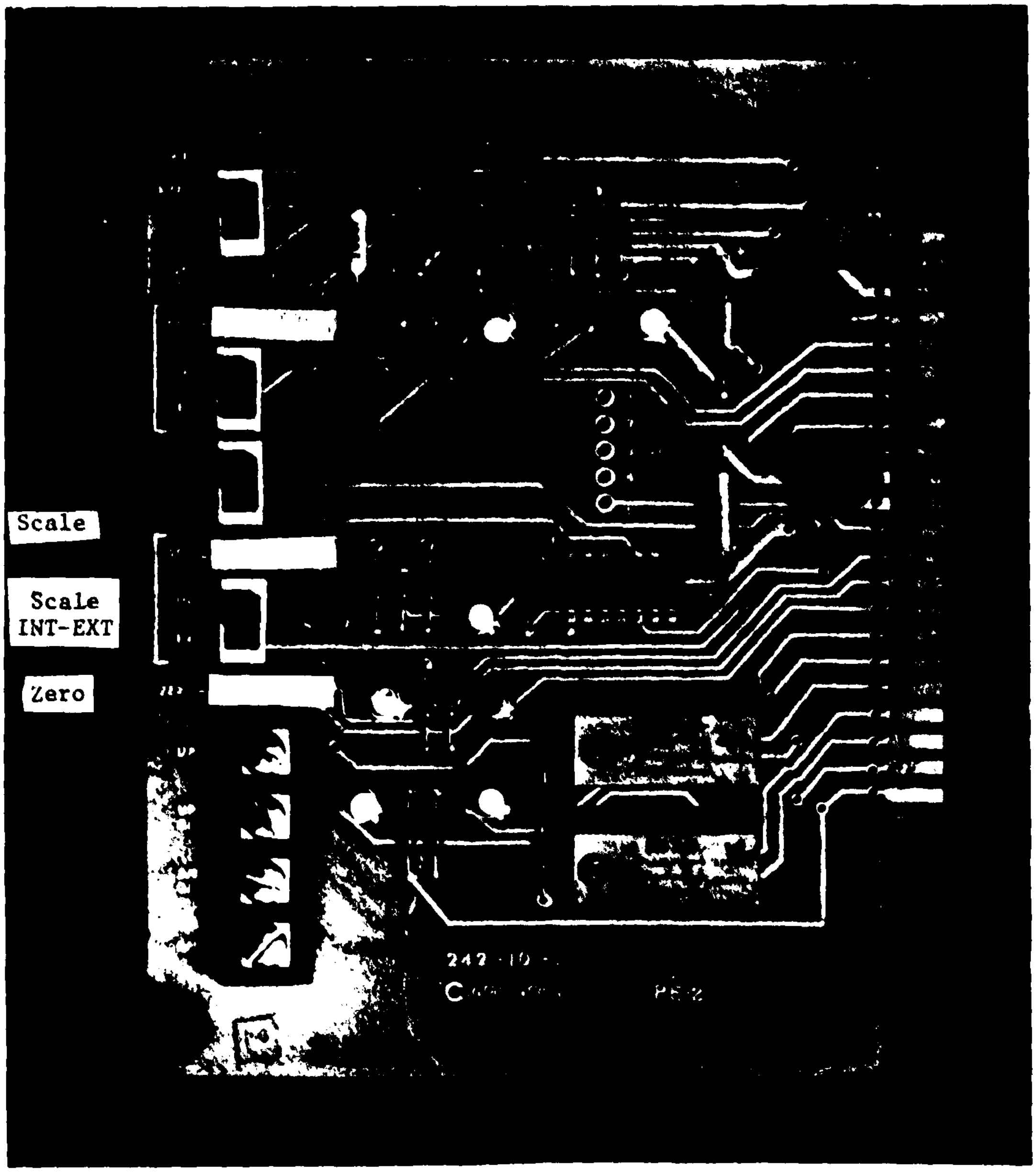

FIGURE 9. FLOWMETER CARD

APPENDIX A

METHOD OF COMPUTING FOULING RESISTANCE

APPENDIX A

METHOD OF COMPUTING FOULING RESISTANCE

The initial clean tube provides the zero baseline for heat transfer measurements from the Wilson plot. The Wilson plot is a linear regression of the reciprocal of flow velocity ($1/v^{0.8}$) versus fouling resistance (1/h) with h being a measure of heat transfer. Procedures for calculation of fouling resistance (Rf) follow:

$$\text{Flow} = \text{Flow} ** (-.8)$$

$$\text{Flow}_{nom} = 6 ** (-.8)$$

$$\text{Flow}_{corrected} = H_{slope} * (\text{Flow} - \text{Flow}_{nom})$$

$$\text{HRNOM} = \text{HCREWTR} - \text{Flow}_{corrected}$$

$$\text{HNOM} = 1/\text{HRNOM}$$

$$\text{Rfoul} = \text{HRNOM} - (H_{intercept} + H_{slope} * \text{Flow}_{nom})$$

In this scheme, the temperature corrected heat transfer (HCREWTR) and flow ($\text{Flow}_{corrected}$) are used to calculate the reciprocal of heat transfer (HRNOM) which in turn results in the corrected heat transfer - h (HNOM). Finally Rf is calculated using Wilson plot slope and intercept along with HRNOM and nominal flow of 6 feet/sec.

These measurements of fouling resistance are not made on individual heat transfer measurements of great accuracy but rather changes in the heat transfer coefficient due to fouling over the clean tube state.

APPENDIX B

LISTOUTS OF CALIBRATION PROGRAMS

APPENDIX B-1

ROUTINE USED TO ACQUIRE DATA REGARDING NUMBER OF GALLONS IN TANK AND CORRESPONDING LOAD CELL VOLTAGES

```
0:  ent "No. of Samples = ", N

1:  ent 725, "D .OS,N1S,EOS,R2,T1,F1"

2:  "L":

3:  ent "No. of Gallons in tank = ", G;0→A

4:  wrt 709, "COOE"

5:  for I=1 to N

6:  red 725,V;wait 1; V+A→A

7:  next I

8:  A/N→V

9:  fmt c2, f12,4;wrt 16, "V = ", V;wrt 16," G = ", G

10: fmt; spc 2; sto "L"

11: end

* 14706
```

APPENDIX B-2

PRIMARY CALIBRATION ROUTINE

```
0:  dim I$[32],P,DC600,2]
1:  ent "ID$ = ",I$
2:  ent "Sampling Interval (sec) = ",P;1000P→Q
3:  ina D;0→N
4:  wrt 725, "D.0S,N1S,E0S,R2,T1,F1"
5:  oni 9, "I";eir 9;fxd 0
6:  dsp "Press CONTINUE to Begin";stp
7:  wrt 9, "U3H,U3=03,U3P"&str(Q)&" /U3G"
8:  "MAIN":if N=600;sto "S"
9:  dsp N;sto -1
10: stp
11: "I":N+1→N;0→A→B
12: for J=1 to 3
13: wrt 725, "R2";wrt 709, "C00E";wait 1;red 725,W;W+A→A
14: wrt 725, "R3";wrt 709, "C01E";wait 1;red 725,F;F+B→B
15: next J
16: A/3→DCN,1];B/3→D[N,2]
17: eir 9;iret
18: "S":
19: ent (Storage File No. = ", K
20: ent "Track No. = ", T
21: trk T;rcf K, I$,P,D[*]
22: end
*5896
```

APPENDIX B-2

PRIMARY CALIBRATION ROUTINE

```
0:  dim I$[32],P,DC600,2]
1:  ent "ID$ = ",I$
2:  ent "Sampling Interval (sec) = ",P;1000P→Q
3:  ina D;0→N
4:  wrt 725, "D.0S,N1S,E0S,R2,T1,F1"
5:  oni 9, "I";eir 9;fxd 0
6:  dsp "Press CONTINUE to Begin";stp
7:  wrt 9, "U3H,U3=03,U3P"&str(Q)&" /U3G"
8:  "MAIN":if N=600;sto "S"
9:  dsp N;sto -1
10: stp
11: "I":N+1→N;0→A→B
12: for J=1 to 3
13: wrt 725, "R2";wrt 709, "C00E";wait 1;red 725,W;W+A→A
14: wrt 725, "R3";wrt 709, "C01E";wait 1;red 725,F;F+B→B
15: next J
16: A/3→DCN,1];B/3→D[N,2]
17: eir 9;iret
18: "S":
19: ent (Storage File No. = ", K
20: ent "Track No. = ", T
21: trk T;rcf K, I$,P,D[*]
22: end
*5896
```

APPENDIX B-3

ROUTINE FOR PLOTTING FLOW VOLUME AS A FUNCTION OF TIME

```
0:  dim I$[32],P,D[600,2];fxd 2
1:  ent "Track No. = ",T,"File No. =",K
2:  trk T;ldf K,I$,P,D[*]
3:  scl -200,800,-10,60
4:  axe 0,0,100,10
5:  for I=1 to 600
6:  -12.5254+120.5238D[I,1]→Y
7:  plt I,Y
8:  next I;pen
9:  plt 100,55,0;lbl I$&", "&str(P)&" seconds"
10: plt 800,60,0; dsp "Change Chart Paper";stp
11: scl -199P,799P,-10,60
12: axe 0,0,30,10
13: ent "Imin=",L,"Imax=",U
14: for I=L to U
15: -12.5254+120.5238D[I,1]→Y
16: plt P(I-1),Y
17: next I;pen
18: plt 100P,55,0:lbl I$
19: plt 799P,60,0;end
*17195
```

APPENDIX B-4

ROUTINE FOR COMPARATIVE PLOT OF MEASURED FLOW VERSUS METERED FLOW

```
0:  dim I$[32],P,D[600,2]
1:  ent "ID$=",I$
2:  ent "Sampling Interval (sec)=",P;1000P→Q;P→R
3:  ina D;0→N
4:  wrt 725,"D.0S,N1S,E0S,R2,T1,F1"
5:  oni 9,"I";eir 9;fxd 0
6:  dsp "Press CONTINUE to Begin";stp
7:  wrt 9,"U3H,U3=03,U3P"&str(Q)&"/U3G"
8:  "MAIN":if N=600;gto "S"
9:  dsp N;gto -1
10: stp
11: "I":N+1→N;0→H→B
12: for J=1 to 3
13: wrt 725,"R2";wrt 709,"C00E";wait 1;red 725,W;W+A→A
14: wrt 725,"R3";wrt 709,"C01E";wait 1;red 725,F;F+B→B
15: next J
16: A/3→D[N,1];B/3→D[N,2]
17: eir 9;iret
18: "S":
19: ent "Storage File No.=",K
20: ent "Track No.=",T
21: trk T;rcf K,I$,P,D[*]
```

APPENDIX B-4 (Continued)

```
22:  fxd 2
23:  I→M
24:  0→P
25:  for I=1 to M
26:  P+D[I,2]→P
27:  next I;P/M→F
28:  (D[M-5,1]-D[5,1])*120.5238/((M-10)*R/60)→L
29:  dsp M,L,2*F
30:  end
*7623
```

APPENDIX C

VOLTAGE OUTPUT OF THE LOAD CELL VERSUS VOLUME

APPENDIX C

VOLTAGE OUTPUT OF THE LOAD CELL VERSUS VOLUME

Volume (Gallons)	Voltage (V)
0	0.1041
5	0.1456
10	0.1869
15	0.2282
20	0.2695
25	0.3111
30	0.3531
35	0.3944
40	0.4357
45	0.4775

APPENDIX D

WORK SHEET OF FLOWMETER CALIBRATION TESTS

APPENDIX D

WORK SHEET OF FLOWMETER CALIBRATION TESTS

Flowmeter Test
NCSC Ammo Pier
18 April 1979

Marked track 0 with files 6 through 19 having 9700 bytes
Marked track 1 with files 0 through 5 having 9700 bytes

	File	ID$	No. Data Points
	6	T5F16,.5	315
	7	T5F18,.5	306
	8	T5F14,.5	380
	9	T5F12,.5	440
	10	T5F10,1.0	265 (least)
	11	T5F8,1.0	340
	12	T4F18,.5	335
	13	T4F16,.5	370
	14	T4F14,.5	425
	15	T4F12,.5	500 (most)
	16	T4F10,1.0	305
	17	T4F8,1.0	395
Trk 1	0	T1F18,.5	305
	1	T1F16,.5	345
	2	T1F14,.5	405
	3	T1F12,.5	455
	4	T1F10,1.0	270
	5	T1F8,1.0	335

APPENDIX E

MAGNETIC TAPE DIRECTORY

APPENDIX E

MAGNETIC TAPE DIRECTORY

Trk 0

File #

#0		
6	664	9700
#1		
3	9648	9700
#2		
3	9648	9700
#3		
3	9648	9700
#4		
0	0	9700
#5		
0	0	9700
#6		
0	0	9700
#7		
0	0	9700
#8		
0	0	9700
#9		
0	0	9700
#10		
0	0	9700
#11		
0	0	9700
#12		
0	0	9700
#13		
0	0	9700
#14		
0	0	9700
#15		
0	0	0

File 0 contains the program listed in Appendix D.
Files 1 through 3 contain data from actual flow calibrations.
Files 4-14 are empty files.

On the HP9825, files indicated above are generated (marked) as follows:

1. Rewind
2. Trk 0, Execute
3. mrk 14, 9700, Execute

DATE
ILMED
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